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ECOLOGY AND CONTROL OF *NEOSORIUS BREVIPENNIS* (COLEOPTERA: STAPHYLINIDAE) ON TURF GRASS IN SOUTH AFRICA

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Very little information on the ecology and pest status of the fossorial rove beetle, *Neosorius brevipennis* Fagel is available (Smetana 1985). These beetles tunnel underground and lay their eggs in clusters of three to ten in the blind ends of tunnels. It was found by sampling and observation that *N. brevipennis* were responsible for casting mounds on golf course putting greens in Johannesburg and Pretoria (Schoeman 1997). Soil castings may damage mowing equipment, interfere with play by deflecting putts, and are objectionable for aesthetic reasons. A study of a fossorial rove beetle (*Osorius planifrons* Leconte), responsible for casting mounds on greens at the Tucson Country Club, Tuscon, AZ, USA, was conducted in the late 1970s. That study included ecological and behavioral analysis and concluded that *O. planifrons* requires high soil moisture and probably feeds on soil microbes (Smith et al. 1978). The authors discussed cultural control but no chemical or biological control methods were addressed.

The objectives of this study were to determine the annual population densities and soil profile distributions of *N. brevipennis* on bent grass (*Agrostis stolonifera* L.) and kikuyu grass (*Penisetum clandestinum* Hochst. ex. Chiov.). The efficacy of chemical controls for *N. brevipennis* was also investigated.

Neosorius brevipennis was sampled at the Wingate Park Country Club (WPCC) in Pretoria, Gauteng, South Africa (25°44'S, 28°15'E). Chemical trials were conducted at Kensington golf course in Johannesburg, Gauteng, South Africa (28°40'S, 25°10'E). The study was conducted from November 1999 to October 2000.

Five random samples were taken with a putting green hole cutter (diameter: 110 mm and depth: 100 mm) on a green (bent grass) and on a fairway (kikuyu grass), respectively, to examine the distribution and population densities of adult and immature rove beetles in the soil profile. Eggs were not included in the study. Soil cores were examined in 25 mm thick sections and all stages found at each depth were recorded. The 10 samples were collected and analyzed monthly from November 1999 to October 2000 to determine the population density of *N. brevipennis* throughout the year. The distribution of *N. brevipennis* between the upper 50 mm and 51-100 mm of the soil profile and between green (bent grass) and fairway (kikuyu grass) samples were compared using the non-parametric Kruskal-Wallis test.

Ten random plots of 0.25 m^2 (0.5 m × 0.5 m) were sampled to determine the mean number of casting mounds per 0.25 m^2. After assessments were made, 100 individual mounds were collected in poly-top-containers and the average dry mass per mound was measured in the laboratory with a Sartorius scale. Data were collected mid-day on putting green 9 at WPCC in mid April 2000, at an average surface temperature of 25.9°C.

The chemical trials were conducted at the beginning of 2000 (8 January-3 March). The infested putting green 12 on Kensington golf course was divided into six blocks of 28 m^2 (3.00 m × 9.33 m). Five chemicals (carbaryl, fipronil, imidacloprid, isofenphos and azinphos-methyl), formulated as a WP, SC, SC, EC and EC, respectively, were tested. Blocks were randomly allocated to each chemical and a control (untreated) area. Insecticides were applied to the turf surface with a backpack sprayer at the typical turf rate (Table 1). Application was followed by irrigation (using the golf course irrigation system) for 9 min (equivalent of

TABLE 1. THE MEAN NUMBER OF SOIL PUSH-UPS PRESENT (AT MID-DAY) PER 0.11 M^2. MEANS WITH LETTERS IN COMMON, ARE NOT SIGNIFICANTLY DIFFERENT ($P > 0.05$).

	Mean number of mounds per week							
Chemical (G AI/ha)	05 DAT	12 DAT	19 DAT	26 DAT	33 DAT	41 DAT	47 DAT	54 DAT
Carbaryl (600)	0.8 a	0.8 a	0.8 a	3.0 ab	3.4 ab	5.6 ab	4.6 a	3.8 ab
Fipronil (75)	10.2 b	24.8 c	7.2 ab	17.4 bc	21.2 c	18.0 c	21.0 d	20.4 c
Imidacloprid (350)	5.4 ab	5.4 ab	2.4 ab	2.4 ab	1.6 a	2.4 ab	2.4 a	1.4 a
Isofenphos (2000)	0 a	0 a	0 a	0 a	0 a	0 a	0 a	0 a
Azinphosmethyl (2100)	19.4 c	18.0 bc	9.0 b	8.4 ab	15.2 bc	15.4 b	10.8 b	9.8 b
Control	40.2 d	53.2 e	39.4 d	39.0 d	34.2 d	53.4 e	49.6 f	45.0 d

10 mm precipitation) to water the insecticides into the soil. The control block was also watered with the same volume. The treated and untreated blocks were monitored weekly (at mid-day) for soil mounds or "push-ups" for eight consecutive weeks, starting 5 d after the single chemical application. Five randomly selected 0.11 m^2 (a circle with a diameter of 375 mm) areas in each block were used to count the number of soil mounds present each week (to test the temporal efficiency of the different chemicals). A MANOVA (Multivariate Analysis of Variance) and post hoc Tukey HSD (Honest Significant Difference) test was used to separate means. The statistical analysis of all the data was conducted on the software program "Statistica", Version: 5 (1995) (Statsoft, Inc.).

Results

Significantly more *N. brevipennis* adults and larvae were found in the soil from the soil surface to a depth of 50 mm (81.05% of beetles sampled) than at a depth of 51 to 100 mm (18.95% of beetles sampled) in the soil profile (Kruskal-Wallis, p = 0.0011). The annual population density variation of *N. brevipennis* is shown in Fig. 1. The relative occurrence of the adults and larvae, over an annual period, indicates the beetles over winter as adults (Fig. 1). Converting numbers to square meters, the maximum (±S.E.) number of rove beetles per square meter was 1620.49 ± 562.35 in October (early summer) and the minimum (±S.E.) number was 294.63 ± 46.53, in June (winter). There was no significant difference between the green (bent grass) and fairway (kikuyu grass) infestation densities (Kruskal-Wallis, p = 0.10) (data not shown).

The average number of mounds (±S.E.) was 61.30 ± 4.78 per 0.25 m^2 (or 245.20 ± 19.12 m^2) with a mean mound mass (±S.E.) of 40 ± 1.64 mg.

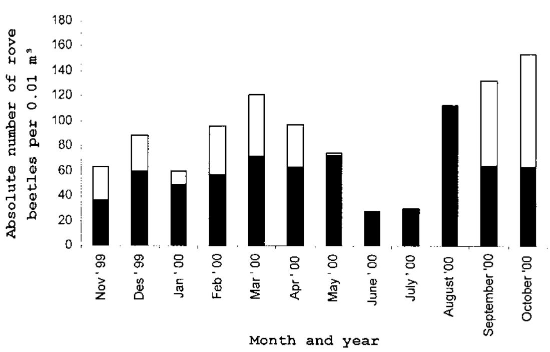

Fig. 1. The proportion of adults (black) and larvae (white) representing the absolute monthly numbers of *N. brevipennis* per 0.01 m^3 (10 samples with a diameter of 110 mm and 100 mm deep) over an annual period (November 1999 to October 2000).

The average number of mounds (±S.E.) equals when standardized to number per square meter.

Table 1 summarizes the weekly mean number of mounds in different insecticide treatments, as well as significant differences between them (MANOVA; Tukey HSD). All the insecticide treated blocks had significantly less soil mounds than the untreated control block over the monitoring period. The isofenphos treated block had no soil mounds present in the eight weeks of monitoring. The soil mounds on the carbaryl and imidacloprid treated blocks were not significantly higher than the isofenphos treated block over the sampling period. The azinphos-methyl and the fipronil treatments were generally significantly less effective than any of the other treatments, but had significantly fewer mounds than the untreated.

Discussion

Populations of adult and larval *N. brevipennis* were concentrated just beneath the grass surface up to a depth of 50 mm in the soil profile. The highest density of rove beetles occurred in the warm, moist, spring and early summer months (Aug.-Oct.). The data suggested that these beetles over wintered as adults. The life expectancy and life cycle length is unknown. The beetles were found in similar numbers on bent and kikuyu grass, with initial infestation usually concentrated on green surrounds (kikuyu grass).

As a result of the tunnelling activity of *N. brevipennis*, aesthetically unacceptable soil mounds are pushed up on the grass surface. The average number of mounds on a putting green per square meter was 245, but up to 400 casts per meter has been reported (Schoeman 1997).

All of the chemicals tested were effective at reducing mounds relative to the untreated control area. Isofenphos was the most effective, resulting in no symptoms (mounds) of infestation for at least 8 wk after application. Carbaryl and imidacloprid were second most and equally effective. Relative to isofenphos, however, carbaryl was more effective than imidacloprid. Azinphos-methyl, followed by fipronil, were the least effective chemicals in the test group.

Summary

The fossorial rove beetle, *N. brevipennis*, tunnels underground primarily in the top 50 mm of the soil profile of bent and kikuyu grass and causes soil mounds on the surface. It is most abundant in late spring and early summer. The most effective insecticide for controlling *N. brevipennis* is isofenphos, but carbaryl and imidacloprid also proved effective. Azinphos-methyl and fipronil and were not found to be highly effective.

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